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A PRELIMINARY REPORT ON AERIAL APPLICATION OF DDT FOR THE CONTROL OF FOREST INSECTS DURING 1944

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The application of insecticides by means of airplanes has been the subject of study for about 20 years. Commercial airplane dusting of cotton for control of the boll weevil has been available to growers for several years. It has proved very effective, and prewar costs were as low as 50 cents to $1 an acre, depending on the terrain and the amount of insecticide used per application. Many attempts have been made by Federal and State agencies and commercial dusting concerns to treat forested areas by means of airplane dusting for control of defoliators. These attempts have been more or less unsuccessful, or at least not practical, because of the inherent difficulties in the use of dusts and the kind of insecticides available, together with the high cost of operation in comparison with the value of the timber to be protected.

Recently experimental work in this field has been renewed, for the purpose of testing the effectiveness of DDT (2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane), when applied in this manner. This material, because of its greater toxicity, can be used in comparatively small quantities per acre and can be readily applied from aircraft as a spray which adheres well to the foliage and other parts of the trees. The work done in 1944 with DDT has given such promising results that it seems desirable to present these results, with the hope that it will encourage further developments, especially by private enterprise. In this paper the data from several experimental tests in a cooperative project carried on by the Division of Gypsy and Brown-tail Moths Control and the Division of Forest Insect Investigations are presented, and suggestions are made for future work.

Two airplanes have been used in this work, a White Standard biplane capable of carrying approximately 700 pounds of pay load, and a Piper cub plane with a capacity of about 250 pounds. The White Standard plane is equipped with a distributing apparatus, the essential features of which consist of two units of four disks each, set at either side of the slip stream and rotated by small air-driven propellers. The spray mixture is fed by gravity onto these disks from a tank within the plane. The spray released from this device is atomized and settles as a fine mist on the forest canopy, penetrating to the understory. In the cub plane the liquid is released under pressure from a series of nozzles attached to a cross pipe under the fuselage. Applications were made at the rate of 5 pounds

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of DDT in 5 gallons of liquid per acre for the earlier work in 1944, with a gradual reduction down to as little as 1/2 pound of DDT in 1/2 gallon of liquid in later applications. Table 1 lists the treatments made during the 1944 season. All of them, with the exception of the Greenfield, N. Y., plot, where the Piper cub plane was used, were applied with the White Standard biplane.

The results of these applications were remarkable in the light of the low dosages used. Complete control of the gypsy moth, the red-headed pine sawfly, and the green-striped maple worm was obtained by using 5 pounds of DDT in 5 gallons of liquid per acre. Complete or nearly complete control of the red-headed pine sawfly and Diprion frutetorum (F.) (another sawfly on pine) was obtained with 2.25 and 2 pounds of DDT in 2.25 and 2 gallons of spray per acre, respectively. Because of the success of these lower dosages, further reductions were made and partial control of D. frutetorum was obtained with 1 pound of DDT in 1 gallon of spray per acre. The observations indicated that the gallonage of spray per acre must be varied according to the volume of foliage per acre to be treated. Tentatively, it appears that where there is relatively little foliage per acre, as in plantations, good control may be expected from 1 pound of DDT in 1 gallon of spray per acre, whereas under forest conditions 2 pounds of DDT in 2 gallons of liquid may be necessary. Further experimentation is essential before definite conclusions can be drawn, because different species of insects vary considerably in their susceptibility to poisoning by DDT.

Flying at 80 miles per hour about 50 feet above the treetops, the White Standard biplane deposited spray over a swath of approximately 120 feet. The distributing apparatus was therefore adjusted to deliver 20 gallons of spray per minute (10 gallons per unit). This rate of distribution is equivalent to 1 gallon per acre. Since this is about the maximum output possible with the apparatus in use at present, areas on which 2, 3, or more gallons per acre were applied were treated two, three, or more times. The apparatus was adjusted to deliver 10 gallons per minute when treatments of 1/2 gallon per acre were desired.

The spinner distributing device worked very well for the type of plane and the type of experimental work undertaken. Plans are under way for modification and improvement of the equipment. It is possible that finer atomization of the spray particles than is obtained at present may prove practical. Tests should also be made with other types of distributing devices, which will utilize the forward motion of faster and larger planes to atomize the spray material. The gas tanks might be used for carriers of the insecticidal spray. Some such devices are now in use by the Army and Navy.

Table 1.--A summary of the application by airplane of DDT against forest insects in 1944

Date	Place	Area treated	Insect	Dosage per acre	Amount of spray used per acre	(Formula) (parts by weight approximately)	Results
				Pounds	Gallons		
May 3	Jefferson, Pa.	20 acres	Gypsy moth (prior to hatch)	5.0	5	DDT, 1 Cyclohexanone, 1 Shell oil, 7	Complete control.
24	Greenfield, N. Y.	5 do.	Gypsy moth (2nd and 3rd stages)	5.0	5	do.	do.
June 27	Algonquin Park, Ont.[1]	8 do.	Spruce budworm (mostly pupae)	5.0	5	DDT, 1 Cyclohexanone, 1 Mentor #29 oil, 7	Results cannot be given until 1945.
27	do.	12.8 do.	do.	3.0	4	do.	do.
27	do.	9.6 do.	do.	2.0	4	do.	do.
30	Brasher, N. Y.	5 do.	Red-headed pine sawfly (mostly larvae)	5.0	5	DDT, 1 Cyclohexanone, 1 Shell oil, 7	Complete control.
30	do.	11 do.	do.	2.25	2.25	do.	do.
July 7	Derby Line, Vt.	5 do.	Green-striped maple worm (larvae)	5.0	5	do.	do.
Aug. 14	Pittston, Pa.	40 do.	[2/]	5.0	5	DDT, 1 Xylene, 1.5 Shell oil, 6.5	
Sept. 16	Litchfield, Conn.	1 swath	Diprion frutetorum sawfly (larvae)	2.0	2	DDT, 1 Xylene, 1.5 Shell oil, 6.5	Good; perhaps complete control.
16	do.	1 do.	do.	1.0	1	do.	Considerable kill but also considerable survival.
16	do.	1 do.	do.	.5	1	do.	Slight kill.
16	do.	1 do.	do.	.5	.5	do.	do.
12	Wendell, Mass.	1 do.	Woodland	3.0	3	do.	Complete kill of caged larvae. [3/]

Table continued

Table 1.--A summary of the application by airplane of DDT against forest insects in 1944 (Cont.)

Date	Place	Area treated	Insect	Dosage per acre	Amount of spray used	Formula (parts by weight approximately)	Results
				Pounds	Gallons		
Sept. 12	Wendell, Mass.	1 swath	Woodland	1.0	1	DDT, 1 Xylene, 1.5 Shell oil, 6.5	Good kill of caged larvae. 3/
20	do.	do.	do.	.5	1	do.	Practically no kill of caged larvae. 3/
20	do.	do.	do.	.5	.5	do.	do.
19	do.	do.	Plantation	1.0	1	DDT, 1 Xylene, 1.5 Shell oil, 3.0 kerosene, 3.0	Complete kill of caged larvae. 3/
19	do.	do.	do.	1.0	1	DDT, 1 kerosene, 7	do.
19	do.	do.	do.	1.0	1	DDT, 1 Xylene, 1.5 kerosene, 6.5	do.
19	do.	do.	do.	1.0	1	DDT, 1 Shell oil, 6.5 fish oil, 0.25 motor oil, 0.05	do.

[1]Tests conducted in cooperation with the Dominion Entomological Branch and the Ontario Department of Lands and Forests.

[2]To determine the effect on water and wild life.

[3]Treated material was brought into the laboratory and tested on caged insects.

If DDT can be applied at the rate of 1 pound in 1 gallon of solvent, i.e., a total of 8 pounds per acre, rather large areas can be covered with one loading of the plane. With larger planes it might eventually be possible to spray almost a square mile with one loading.

At the present time intense interest is being shown in the possibilities of applying DDT from airplanes for the control of the spruce budworm. Unfortunately, it will not be possible to evaluate the results of aerial applications made in 1944 against this insect until the summer of 1945. The Division of Forest Insect Investigations was able to make rather extensive tests with high-powered ground equipment in Colorado. Dosages of 2.5, 5, and 10 pounds per acre were applied. Some of these sprays were out on prior to larval activity in the spring; others were used when the larvae were from one-half grown to full grown. All applications totaling over 20 acres resulted in almost perfect control of the spruce budworm. It is possible that the early applications, which killed the young larvae as they began feeding, were partially effective against the adults several weeks later. If so, this would indicate that the benefits from the treatment might carry over to the second year.

The effect of DDT on beneficial insect life and on wildlife has been given some consideration and needs careful and intensive study in the coming season. Much more information on such problems is desirable, if not necessary, before recommendations can be made for using DDT over extensive forested areas. It may be stated briefly that DDT, applied at the rate of 5 pounds per acre, has killed a wide variety of insect life within the area, including beneficial insects such as predators and parasites. On the relatively small areas treated, however, the insect fauna seemed to be back to normal within 10 or 12 weeks. The treatment also killed small numbers of small fish, crayfish, and frogs as well as aquatic insects.

It is believed that the experimental work with DDT in 1944, although rather limited, warrants an optimistic attitude toward its use in the future. There are, of course, many kinks that must be ironed out but, all in all, it appears that DDT can be used as a spray from aircraft for the control of defoliating insects with dosage requirements sufficiently low to make it practical to cover large areas of forest. More attention must be given to the selection of the most suitable type of plane and to the improvement of distributing devices. These problems have been extensively discussed with engineers and work is going forward. Some workers think that larger planes, capable of carrying a ton or more of insecticide, are needed. It is probable that planes of slow speed--around 100 miles per hour--would be more suitable than faster ones, because they could be handled closer to the treetops. Larger planes could probably be flown at somewhat higher elevations, say 100 feet, permitting a greater factor of safety to the pilot, as well as covering a wider swath. It is not necessary to obtain complete control of

most forest insects; a reduction of the defoliation to such an extent that the trees will not succumb would be sufficient. Coverage, therefore, need not be complete, and perfect lapping of the swaths would not be necessary. The more heavily infested spots could be selected and treated first. With some insects, for example, the spruce budworm, it may be possible to control two generations with one application of the insecticide. It is also probable that fairly good coverage at the beginning of an outbreak would prevent subsequent build-up of infestation, and satisfactory control might be obtained with only one application.

More study is needed on marking devices, in order to permit rapid lining of the swaths by the aviators. For this purpose chemical dyes and balloon markers are being investigated.